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Fuel Station Trips Generation on Arterial Road in Thailand: A Case Study on Chonburi Province

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Abstract*— Fuel station in Thailand has served different types of fuel and activities in the station. This is the key reason the service user chooses to use other services besides filling fuel; this is different from others parts of the world. In analyzing the trips generation, it is necessary to consider factors from activities within fuel station located on the arterial road where the traffic is crowded as it is characterized by the uniform distribution of traffic during the day, with main factors for making decision to choose service of fuel station consisting of traffic volume, size of the area of fuel station, density of fuel station, and the number of dispensers. In this study, the model for prediction traffic volume into and out of the fuel station was created. It was found that the non-linear model in compound regression form was the best one in prediction as there was low level of error with R2 of 0.692 for model predicting trips into station, and of 0.728 for model predicting trips out of the station. When considering proportion of peak hour, it was found that the trips into the station were 6.27 percent per day and the trips out of the station were 6.48 per day during 9.00 am. – 10.00 am. Also, it was found in this study that trips into and out of the fuel station located on the arterial road during holiday were more than those on working days; this is different from that found by the Institute of Transportation Engineers (ITE)'s method. However, ITE's method in analyzing trips generation of fuel station located on arterial road can still be used but only that there is reduction of proportion of peak hour to half from the requirement and it would provide analysis result that is closer to the real condition.

***Index Terms*— Trips generation, Trips attraction, Fuel station, Arterial road.**

I. INTRODUCTION

The analysis of trips generation is the first step of the four-step traffic plan process used in planning the traffic, and it is the traffic impact assessment. In various countries, the determination of trips generation of more than 100 trips per hour in peak hour is popular. The analysis report of traffic impact must be prepared in order to solve traffic problem arising from activities. Generally, it is popular to use the method of the Institute of Transportation Engineers (ITE), which is convenient and easy in analyzing trips generation. According to the logistics report 2014 of the Office of the National Economic and Social Development Board of Thailand, it was found that, in Thailand, the transportation on the road is more than 80.4 percent, secondary it is the transportation on rail of 2.2 percent and on air of 0.02 percent, while the transportation by water is 9.0 percent, finally it is the Transportation via sea coast of 8.4 percent. This shows that land transport by road is major of transport in Thailand. In 2015, Thailand has 36,679,180 vehicles and population of 65,124,716 persons or vehicle ownership 1.78 person per vehicle. That is energy for land transport by road of 21,385 kiloton of oil equivalent more than 80 percent for energy transport all over of Thailand.

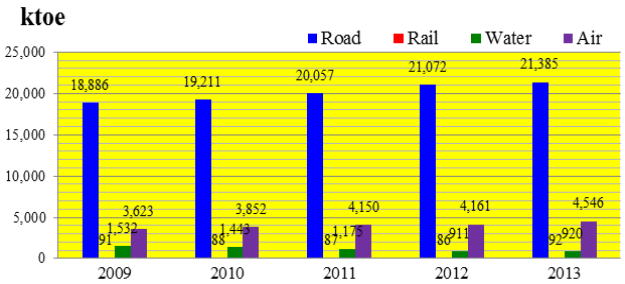

Fig 1: Sharing of transport modes in Thailand

Fuel station in Thailand has gasoline, diesel, natural compression gas (CNG) and liquid petroleum gas (LPG) and in the station, there would be convenient store, car wash, tire service, coffee shop, food park and other shop in fuel station in Thailand, but ITE method is found to be different in that there are only 3 forms of activities of the fuel stations that are fuel service, convenient store, and car wash service. This finding does not cover all activities in fuel station of Thailand. Therefore, it is necessary to do this research in order to cover all activities as found in fuel station in Thailand so that the trips generation could be done appropriately, especially that is on arterial road where the traffic volume is very high; this is the main objective of this study since it is the area where there is intense impact on both sides of the traffic way on arterial road from activities of fuel station.

Trips generation is the first step in four-step model for transport planning. Generally, process there are 2 methods to analyze including the Early method difficulties in analyzing where with relatively plenty data in area study, and Institute of Transportation Engineers (ITE) method with size activity relation facile consist 10 types of activity: 1) Port and Terminal, 2) Industrial, 3) Residential, 4) Lodging, 5) Recreational, 6) Institutional, 7) Medical, 8) Office, 9) Retail and 10) Services. Fuel station is services activity by ITE consist code 944 Gasoline/Service station, code 945 Gasoline/Service station with convenience market and code 946 Gasoline/Service station with convenience market and car wash. ITE method analyzing procedures to estimate trips for generate daily trips by size of activity and distribution peak hour trips by percent of P.M. peak rate.

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Then dividing trips attraction and trips production by IN-OUT proportion. (9th Trips generation guild book)

In 2007 Rajamangala University of Technology Thanyaburi by Somchai Thams arnong and Assistant Professor Suphunee In-Kaew showed Marketing Factors affect to behavior of using gasoline station of personal car drivers in Bangkok metropolitan consist sex, age, vocation, income, vehicle brand, time and type of fuel has relative to frequency of customer behavior service.

In 2008, Burapha University by Vicha Phukanont show factor of choose service fuel station in Wang Nam Yen district Sa-Kaeo province consist of age education vocation and income effect service fuel station choose and most customer choose for quality of gasoline, clean toilet and lucidly price sign.

In 2011, ITE-western meeting Anchorage Washington, D.C, USA by Christine Eary, Erik Ruehr, and Richard Lee refer to major variable of trips generation in San Diego city find Employment, Land area, Jobs/population diversity, Land used, household size and Vehicles owned.

In 2012, 25thARRB Conference Perth Australia 2012 by Amir Mousavi and Prof. Jonathan Bunker and Dr. Brian Lee refer to 3 variable effect trips generation, there are demographic factors including (Household structure, age, gender and marital status) Social–Economic (Income, Employment and Car Ownership) and Urban form (Population density, Residential/retail/employment density, Distance to transit and Street connectivity)

That concluded the primary advent of travel depends on gender, age, income, vehicle occupants, household size, area activities, density of activity. The activity located on Main Street is associated with Traffic on Main Street. The fuel stations on Major Arterial road have variable of bathroom cleanliness and comfort involved

II. METHODOLOGY

This study has 3 steps consisting of first step to data survey for model creation and model validation, second step to trips generation analysis for model development and final step valuation error for the model as shown in Figure 2.

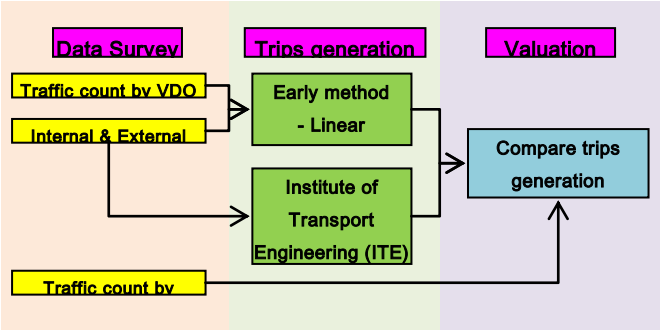

Fig 2: Research Methodology

A. *Study Area*

Chonburi city is the major province of Eastern Thailand. There is center of industries in Thailand and international sea port (LaemChabang) with tourist attraction (Pattaya) and 3rd international airport (U-tapao). The road network in Chonburi province consist Interstate road for Motorway number 7 and major arterial road for highway number 3 (Sukumvit road), highway number 344 (Chonburi – Banbung) and highway number 361 (bypass Chonburi). This area study concentrate Chonburi central business district (CBD) and Ban Bung district in Chonburi province, then stays on co-ordinates 13.360552° North 100.990557° east. This study concentrates on 35th fuel station on 2 major arterial roads in Chonburi province consist highway number 344 and highway number 361 as shown in Figure 3.

Fig 3: Map area study

Highway number 344 (Chonburi – Banbung) is major road linking Chonburi province with Banbung district and major road link to Eastern of Thailand. There is 4 lanes- reinforce concrete pavement and divided median with 30 meters right of way. It has high traffic over 50,000 vehicles per day and percentage of heavy vehicle over 35 percentage. The road in section study has 18 fuel stations. (shown in Figure 4)

Fig 4: Highway no.344 Chonburi – Ban bung

Highway number 361 (Bypass Chonburi) is a major road for diverting thought traffic on Highway number 3 that pass through Chonburi city, then has 60 meters right of way and 12 lanes divided median asphaltic pavement in first section (8 lanes for main road, 4 lane frontage road). Remainder route section is 8 lanes, then have traffic volume over 80,000 vehicles per day and percentage of heavy vehicle over 35 percentage with 19 fuel stations in sideway. (see Figure 5)

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Fig 5: Highway no.361 Bypass Chonburi

B. Data survey

The survey traffic count by VDO commander leads to trips attraction and trips production every 15 minute for that dependent variable, when pneumatic count surveyed every hour for valuation trips generation with model study and Institute of Transportation Engineers (ITE). This is study data survey internal and external activity for dependent variable and roadside interview in fuel station on customer behavior.

C. Trips generation analysis

This study is divided into 2 types including early method and ITE method. The early method then consists of 2 types regression consists linear and nonlinear. None linear regression has 9 types consist Logarithmic, Inverse, Quadratic, Cubic, Compound, Power, S, Growth and Exponential, when choose the better regression by minimum error compare with field survey as shown in Table 1.

TABLE 1: TYPE OF REGRESSION STUDY

Model		Equation
Linear		$y = b_0 + b_1 X$
None linear	Logarithmic	$y = b_0 + b_1 \ln(X)$
	Inverse	$y = b_0 + b_1 \frac{1}{X}$
	Quadratic	$y = b_0 + b_1 X + b_2 X^2$
	Cubic	$y = b_0 + b_1 X + b_2 X^2 + b_3 X^3$
	Compound	$y = b_0 b_1^X$
	Power	$y = b_0 X^{b_1}$
	S	$y = e^{b_0 + \frac{b_1}{X}}$
	Growth	$y = e^{b_0 + b_1 X}$
	Exponential	$y = b_0 e^{b_1 X}$

ITE method has 2 conceptual analysis consist concept 1) is gasoline station stand along has 3 types: gasoline, gasoline with convenience store and gasoline with convenience store with car wash, and concept 2) is analysis of area characteristic combined activity in fuel station in Thailand as shown in Table 2.

TABLE 2: TRIPS GENERATION ITE CODE

ITE Fuel station	ITE combine fuel station with other activity							
Gasoline station	Gasoline station	Shopping center (Shop)	Sit-down restaurant	Quick Lubricant	Convenient market	Tire store	Self-car wash	Drinking place
944 945 (Convenient.) 946 (Convenient. + carwash)	944	820	932	941	851 (16 hr) 852 (24 hr)	848	947	925

Remark: 9th Trips generation guild book, ITE

D. Model Validation

The final part of this study is that it is necessary to fine the confidence level of model in predicting the traffic volume in and out of the fuel station; this would be done by comparing the lowest level of error of the model with the real condition as found in the survey by automatic counting machine. In this study, it was the comparison of model form the Early Method and the ITE's method with the real result as found in the field survey by automatic counting machine during the whole day and during peak hour, in order to find the lowest-error method of analysis of trips generation in and out of the fuel station, which is the method that is suitable for the condition of fuel station located on arterial road.

III. RESULTS

The VDO commander survey that was performed on Sunday 21 December 2014 to Sunday 25 January 2015 from 8 fuel stations at highway number 344 Chonburi – Ban bung and highway number 361 Bypass Chonburi. The survey finds traffic entrance-exit fuel station in weekday more than holiday. Arterial road survey has traffic volume 15,000 – 38,000 vehicle per day per direction on highway number 344 and 35,000 – 58,000 vehicles per day per direction on highway number 361 and percentage of heavy vehicle average 25 percent in weekday and decrease to 20 percent in holiday with percentage of motorcycles average 6 percent in weekday and increase to 10 percent in holiday.

This survey found trips attraction and trips production of fuel station variant from 500 to 5,000 trips per hour of 8 station characteristic. However, the most fuel station high service trips are gasoline and diesel fuel station service more than gas fuel station. (Shown in Figure 6)

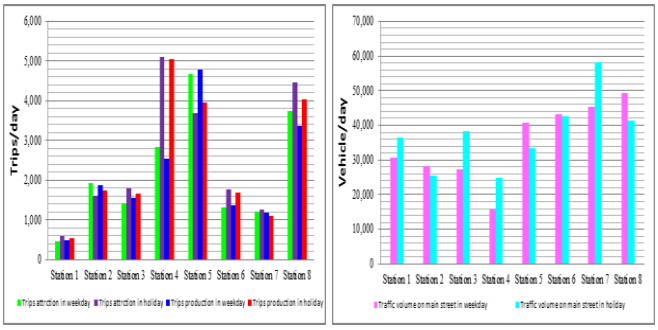

Fig 6: Trips generation and Traffic volume on main street survey

This survey consists of arrival distribution of traffic volume entrance–exit fuel station on arterial road ever daily has peak time in 6.27 percentage of trips attraction and 6.48 percentage of trips production in 9.00 P.M. to 10.00 P.M. of daily. Trips generation has uniform arrival rate in daytime startup 5 percentages in 6.00 P.M. increase to peak in 9.00 P.M and usually over 5 percentages until to 18.00 A.M. that afterwards decrease to night time as shown in Figure 7.

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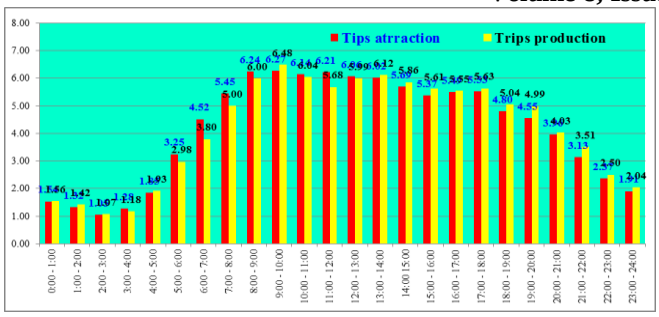


Fig 7: Trips attraction & Trips production hour distribution (%)

This survey consists of vehicle type entrance service in type of fuel station in Thailand classified into 3 types: 1) oil station has service gasoline and diesel oil, 2) NGV station service fuel compression natural gas or natural gas vehicle in Thailand and 3) LPG station has service liquid petroleum gas. The oil station has most service by passenger car under 7 seats, Light truck and light bus service almost and weekday service more than holiday except light truck. NGV station has most service by car under 7 seats, light truck, light bus and semi tailor most service and holiday service more than weekday but light truck service in weekday more than holiday. Finally, LPG station has most service by passenger car under 7 seats and Light truck and holiday morn than weekday (shown in Figure 8).

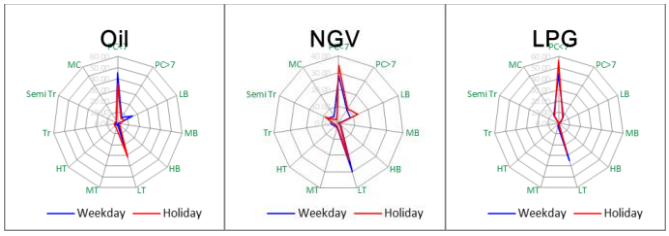


Fig 8: Population type of vehicle service by type of fuel station (%)

There are 1,114 samples for roadside interview by customer in fuel station on arterial road, the study found that the trips behavior has 11.22 percent travel internal zone, 13.91 percent entrance-exit zone and 22.53 percent passing zone. However, trips classification on arterial road find 11.22 percent local traffic and 88.78 percent through traffic. This is general of major arterial road as shown in Figure 9.

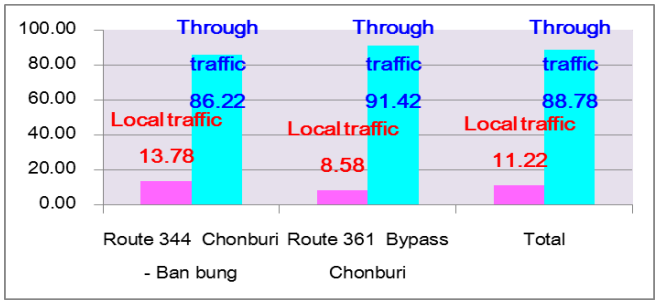
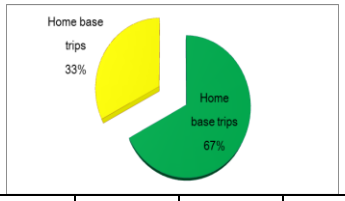


Fig 9: Trips classification on street survey (%)

That is objective of trips two for third relate to home base in 67 percent of sample road side interview as shown in Figure 10.

Customer sample survey found that driver and passenger in vehicle for roadside interview are 6.56 person/vehicle in heavy bus, 3.80 person/vehicle in median bus, 3.46 person/vehicle in light bus, 2.96 person/vehicle in median truck, 2.83 person/vehicle in passenger under 7 seat, 1.98 person/vehicle in light truck, 1.91 person/vehicle in passenger car over 7 seat, 1.80 person/vehicle in motorcycle, 1.66 person/vehicle in heavy truck, 1.61 person/vehicle in semi-tailor and 1.57 person/vehicle in tailor as shown in Figure 11.



	Home base trips	None - Home base trips	Total	% Home base trips	% None - Home base trips
Total	908	423	1,296	67.36	32.64

Fig 10: percentage of trips classification on street survey

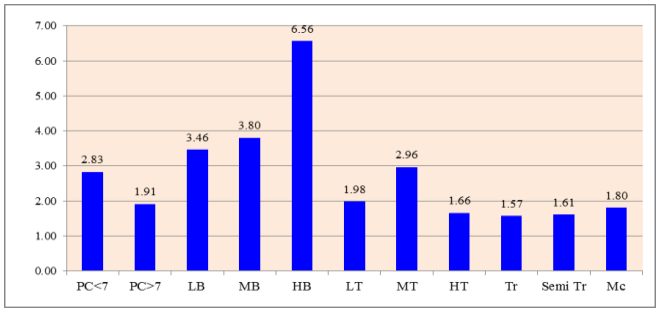


Fig 11: driver & passenger (person/vehicle)

The objective service in fuel station find the most customer need to re-fuel and toilet which consist 4.52 level for re-fuel, 4.23 level for toilet, 2.65 level for shopping, 2.40 level for food eating, 2.10 level for rest, 2.00 level for other activity, 1.81 level for tire service inflation, 1.59 level for tire service recap, 1.55 level for car wash and 1.53 level for lubricate service as shown in Figure 12.

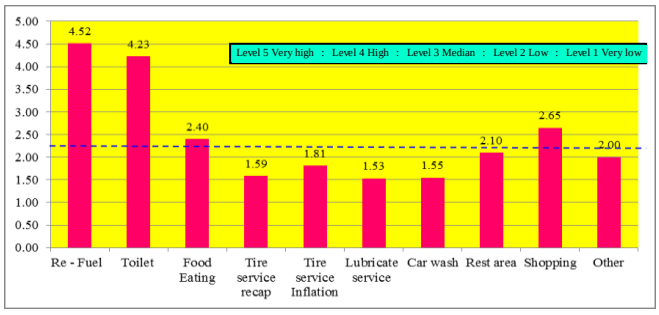


Fig 12: Objective customer service in fuel station

The questionnaire of day time service for roadside interview, most customers that is 32.08 percent of use service on Saturday, 20.33 percent on Monday, 19.02 percent on Sunday, 10.37 percent on Friday, 9.06 percent on Tuesday, 4.57 percent on Wednesday and Thursday.

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However, the most customers choose service in holiday more than weekday as shown in Figure 13.

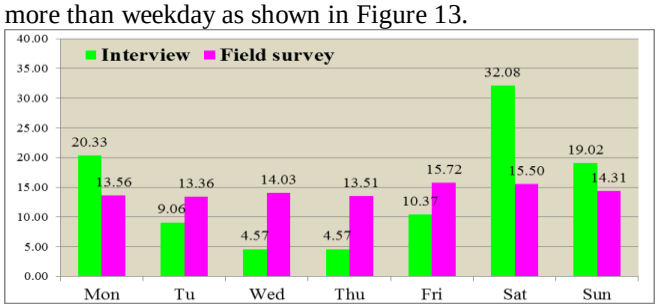

FIG 13: CUSTOMER SERVICE DAY DISTRIBUTION (%)

Summary of hours in a day distribution compare by VDO commander with roadside interview survey find all survey peak hour of day in 9.00 - 10.00 PM. There are VDO commander survey finds 6.33 percent in weekday, 6.41 percent in holiday and 6.37 percent in daily but roadside interview find 15.01 percent in daily. This is percent of peak rate in hour has difference for roadside interview more than VDO commander survey as shown in Figure 14.

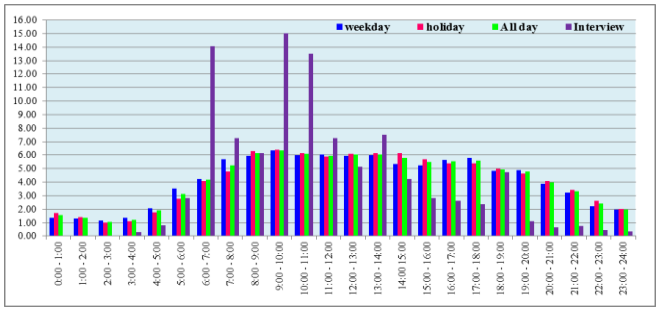

Fig 14: Customer service hour distribution (Trips generation) (%)

Peak rate trips generation by Institute of Transportation Engineers (ITE) have been introduce peak hour rate of gasoline station among 13.38 percent of daily to 13.94 percent of daily. There is double peak rate more than field survey.

According to the study, the data on the volume of trips into and out of the fuel station including the traffic volume on arterial road in the location of fuel station, form manual count method by VDO commander and from the survey of area where there are activities in the station, as well as the factors outside the area where there are activities of fuel station, were analyzed to create regression model inform of linear regression and non-linear regression; this is the independent separation between the volume of traffic into the fuel station and the volume of traffic out of the fuel station, this is different form ITE's method; it was found that, the significant variable is the traffic volume on arterial road, size of the area of fuel station, the number of dispensers, the density of fuel stations located on routes of food center area, convenience store area, that affect the trips generation into and out of the fuel station located on arterial road. The mathematic model can be drawn to conclude on the prediction of the trips generation into and out of the fuel station located on arterial road, as shown in Equation 1.1-10.2.

A. *Linear model*

$$\text{Daily trips attraction} = -1{,}092.106 - 0.041 Traffic\ volume + 1{,}722.834 density + 2.082 Convenient\ store + 10.039 food\ park + 78.015 dispenser \quad (1.1)$$

$$R^2 = 0.780$$

$$\text{Daily trips production} = 440.579 - 0.051 Traffic\ volume + 7{,}780.834 density + 1.182 Convenient\ store + 8.436 food\ park + 100.746 dispenser \quad (1.2)$$

$$R^2 = 0.730$$

B. *Logarithmic model*

$$\text{Daily trips attraction} = -6{,}514.072 - 189.454 \ln(Traffic\ volume) + 1{,}364.042 \ln(density) + 509.998 \ln(Total\ area) + 2{,}083.933 \ln(dispenser) \quad (2.1)$$

$$R^2 = 0.541$$

$$\text{Daily trips production} = -13{,}382.274 - 103.144 \ln(Traffic\ volume) + 1{,}986.320 \ln(density) + 972.064 \ln(Total\ area) + 1{,}902.604 \ln(dispenser) \quad (2.2)$$

$$R^2 = 0.560$$

C. *Inverse model*

$$Daily\ trips\ attraction = 8{,}523.919 + \frac{14{,}761{,}147.247}{Traffic\ volume} - \frac{5{,}624.39}{density} - \frac{3{,}023{,}838.871}{Total\ area} - \frac{20{,}252.674}{dispenser} \quad (3.1)$$

$$R^2 = 0.443$$

$$Daily\ trips\ production = 9{,}706.338 - \frac{23{,}743{,}871.407}{Traffic\ volume} - \frac{6{,}494.907}{density} - \frac{5{,}894{,}583.812}{Total\ area} - \frac{18{,}295.274}{dispenser} \quad (3.2)$$

$$R^2 = 0.460$$

D. *Quadratic model*

$$\text{Daily trips attraction} = 73{,}098.043 + 0.245 Traffic\ volume - 3.07E^{-6} Traffic\ volume^2 - 93{,}301.553 density + 28{,}977.070 density^2 + 29.275 Convenient\ store - 0.066 Convenient\ store^2 - 588.292 dispenser + 18.862 dispenser^2 \quad (4.1)$$

$$R^2 = 0.894$$

$$\text{Daily trips production} = 73{,}555.37 + 0.265 Traffic\ volume - 3.37E^{-6} Traffic\ volume^2 - 94{,}005.261 density + 29{,}303.603 density^2 + 36.173 Convenient\ store - 0.088 Convenient\ store^2 - 683.071 dispenser + 21.334 dispenser^2 \quad (4.2)$$

$$R^2 = 0.895$$

E. *Cubic model*

$$\text{Daily trips attraction} = 633{,}439.087 + 0.475 Traffic\ volume - 6.03E^{-6} Traffic\ volume^2 - 2.373E^{-12} Traffic\ volume^3 - 1{,}135{,}783.456 density + 662{,}897.398 density^2 - 127{,}081.900 density^3 \quad (5.1)$$

$$R^2 = 0.494$$

$$\text{Daily trips production} = 447{,}896.192 + 0.617 Traffic\ volume - 9.96E^{-6} Traffic\ volume^2 - 3.151E^{-11} Traffic\ volume^3 - 792{,}025.544 density + 450{,}438.656 density^2 - 83{,}700.741 density^3 \quad (5.2)$$

$$R^2 = 0.455$$

F. *Compound model*

$$\text{Daily trips attraction} = -5{,}743.183 + (5{,}077.911 \times 1.00^{Traffic\ volume}) - (0.001 \times 1{,}490.236^{Density}) + (27.362 \times 1.00^{Total\ area}) + (289.672 \times 1.09^{dispenser}) \quad (6.1)$$

$$R^2 = 0.692$$

$$\text{Daily trips production} = -7{,}540.137 + (6{,}966.003 \times 1.00^{Traffic\ volume}) - (0.001 \times 2{,}015.938^{Density}) + (32.133 \times 1.00^{Total\ area}) + (211.861 \times 1.10^{dispenser}) \quad (6.2)$$

$$R^2 = 0.728$$

G. *Power model*

$$\text{Daily trips attraction} = 1{,}137.613 + 1.512E^{-7} Traffic\ volume^{1.926} + 9.454E^{-12} density^{49.803} + 7.686E^{-8} dispenser^{7.475} \quad (7.1)$$

$$R^2 = 0.652$$

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$$Daily\ trips\ production = 972.307 + 0.106 Traffic\ volume^{7.555} + 6.04E^{-13} density^{54.418} + 2.288E^{-12} dispenser^{10.708} \quad (7.2)$$

$R^2 = 0.677$

H. S model

$$Daily\ trips\ attraction = -188{,}885.884 + exp^{\left(12.171+\left(\frac{489.376}{Traffic volume}\right)\right)} + exp^{\left(54.895+\left(\frac{89.180}{density}\right)\right)} + exp^{\left(14.224+\left(\frac{69.194.324}{Total\ area}\right)\right)} \quad (8.1)$$

$R^2 = 0.595$

$$Daily\ trips\ production = -238{,}771.929 + exp^{\left(12.400+\left(\frac{372.776}{Traffic volume}\right)\right)} + exp^{\left(49.758+\left(\frac{79.384}{density}\right)\right)} + exp^{\left(14.275+\left(\frac{68.874.354}{Total\ area}\right)\right)} \quad (8.2)$$

$R^2 = 0.653$

I. Growth model

$$Daily\ trips\ attraction = -234{,}422.445 + exp^{7.095} + exp^{\left(12.326+\left(2.31E^{-7} Traffic\ volume\right)\right)} + exp^{(7.622+0.711 density)} + exp^{(0.699+0.022 Convenient\ store)} + exp^{(-8.519+0.067 Food\ park)} + exp^{(-52.056+2.282 Dispenser)} \quad (9.1)$$

$R^2 = 0.918$

$$Daily\ trips\ production = -221{,}619.730 + exp^{6.567} + exp^{(12.287+(2.08E^{-7} Traffic\ volume)} + exp^{(5.902+1.339 density)} + exp^{(2.096+0.017 Convenient\ store)} + exp^{(-6.744+0.059 Food\ park)} + exp^{(-25.315+1.257 Dispenser)} \quad (9.2)$$

$R^2 = 0.899$

J. Exponential model

$$Daily\ trips\ attraction = -71{,}151.700 + 64{,}359.032 exp^{7.80E^{-7} Traffic\ volume} - 1{,}095.282\ exp^{0.962 density} + 635.289\ exp^{1.518E^{-4} Total\ area} + 7.575\ exp^{0.017 Convenient\ store} + 3.521E^{-5} exp^{0.074 Food\ park} + 1.116E^{-26} exp^{2.576 dispenser} \quad (10.1)$$

$R^2 = 0.918$

$$Daily\ trips\ production = -1{,}217{,}296.864 + 1{,}218{,}618.949 exp^{3.75E^{-5} Traffic\ volume} - 607.093\ exp^{-16.694 density} + 4.208\ exp^{6.112E^{-4} Total\ area} + 1.854\ exp^{0.025 Convenient\ store} - 2{,}419.602 exp^{1.62E^{-3} Food\ park} + 6.282 exp^{0.196 dispenser} \quad (10.2)$$

$R^2 = 0.899$

Trips generation model analysis chooses minimum error compare to field survey by pneumatic trip generation. Compound regression and linear regression are the minimum error comparing with the field survey. The trip estimate error of compound regression is 248.54 percentages for daily trips and 128.60 percentages for peak hour trips. The trip estimate error of linear regression is 290.41 percentages for daily trips and 130.67 percentages for peak hour trips.

That model regression study trip is estimate error more than ITE method by gasoline standalone and combine activity in zone of fuel station. ITE method by gasoline standalone estimate trip generation error compare field survey more than ITE method by combine activity as shown in Table 3.

Table 3: Compare error trips generation model with field and ITE method

Type	Trips generation daily			Trips generation peak			Trips attraction peak			Trips production peak			Average Error			
	Model study with	Field survey with	Field survey with	Model study with	Field survey with	Field survey with	Model study with	Field survey with	Field survey with	Model study with	Field survey with	Field survey with	Model study with	Field survey with	Field survey with	R^2
Linear	**290.41**	**55.38**	**55.15**	**130.67**	**55.78**	**82.94**	**147.68**	**53.84**	**84.84**	**129.42**	**77.73**	**79.63**	**174.55**	**60.68**	**75.64**	**0.755**
Logarithmic	690.51	55.38	55.15	273.07	55.78	82.94	267.68	53.84	84.84	292.74	77.73	79.63	381.00	60.68	75.64	0.551
Inverse	1,224.53	55.38	55.15	479.47	55.78	82.94	450.25	53.84	84.84	535.62	77.73	79.63	672.47	60.68	75.64	0.452
Quadratic	459.16	55.38	55.15	185.75	55.78	82.94	199.95	53.84	84.84	185.02	77.73	79.63	257.47	60.68	75.64	0.895
Cubic	133.58	55.38	55.15	646.55	55.78	82.94	685.86	53.84	84.84	626.47	77.73	79.63	822.37	60.68	75.64	0.475
Compound	**248.54**	**55.38**	**55.15**	**128.60**	**55.78**	**82.94**	**109.69**	**53.84**	**84.84**	**147.27**	**77.73**	**79.63**	**158.53**	**60.68**	**75.64**	**0.710**
Power	721.28	55.38	55.15	302.25	55.78	82.94	305.08	53.84	84.84	312.78	77.73	79.63	410.35	60.68	75.64	0.665
S	1,114.36	55.38	55.15	466.79	55.78	82.94	499.60	53.84	84.84	455.36	77.73	79.63	634.03	60.68	75.64	0.624
Growth	386.55	55.38	55.15	179.35	55.78	82.94	193.65	53.84	84.84	175.92	77.73	79.63	233.87	60.68	75.64	0.909
Exponential	552.94	55.38	55.15	275.95	55.78	82.94	253.90	53.84	84.84	318.32	77.73	79.63	350.28	60.68	75.64	0.909

IV. Conclusion

In this study, it was found that the method for analyzing trips generation called the early method by linear regression provides reliable result in terms of error, which is not different from non-linear regression, in estimating the traffic volume of trips into the fuel station located on arterial road. However, the ITE's method in analyzing trips generation is the most reliable one in this study.

If the peak hour rate is adjusted to be 6.37 percent, from the field survey, it is found that be able to reduce error of the estimation for the trips generation into the fuel station located on arterial road for 1.35 percent. In the case when considering only one fuel station, or when various activities are considered in total, the reduction of error would be at 19.59 percent as shown in Table 4.

Table 4: Compare error trips generation model ITE method with field Adjust Reduce P.M. peak rate to 6.37 percent

ITE method		Field survey with ITE standalone				Field survey with ITE combine			
		Trips generation daily	Trips generation peak	Trips attraction peak	Trips production peak	Trips generation daily	Trips generation peak	Trips attraction peak	Trips production peak
Peak rate standard	Mean	55.38	55.78	53.84	77.73	55.15	82.94	84.84	79.63
	Var	857.60	1,287.46	1,204.11	6,907.14	772.89	215.72	301.61	5,675.06
	S.D.	29.28	35.88	34.70	83.11	27.80	14.69	17.37	75.33

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Adjust Peak rate	Mean	55.38	55.04	54.92	79.77	55.15	69.36	69.83	42.83
	Var	857.60	8,614.68	7,296.73	7,860.31	772.89	5,759.91	6,554.89	40,839.62
	S.D.	29.28	92.82	85.42	88.66	27.80	75.89	80.96	202.09
% Difference		0.00	1.35	2.01	2.63	0.00	19.59	21.50	85.92

It was concluded that this study can make suggestion in analyzing trips generation of fuel stations located on arterial road where the traffic volume is more than 30,000 vehicles per day; the peak hour proportion should be reduced to half so that the prediction would be more accurate with the condition of location of the activities.

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REFERENCES

[1] Amir Mousavi, Jonathan Bunker and Brian Lee, A New Approach for Trip Generation Estimation for Use in Traffic Impact Assessments, 25th ARRB Conference – Shaping the future: Linking policy, research and outcomes, Perth, Australia 2012,

[2] Christine Eary, Erik Ruehr, and Richard Lee, San Diego's Mixed Trip Generation Model for Smart Growth and Mixed-use Developments, AK, USA; ITE-western meeting Anchorage, 2011

[3] Institute of Transportation Engineers (ITE), 9th Trips generation guide book, DC, USA, 2012

[4] Institute of Transportation Engineers (ITE), Trip Generation Analysis, Transportation Planning Handbook, p. 108-112. , 1992

[5] National Cooperative Highway Research, Trip Generation Rates for Transportation Impact Analyses of Infill Developments, program report 758, DC, USA, 2013

[6] Somchai Thamsarnong and Suphunee In-Kaew, The Marketing Factors That Affect To Behavior of Using Gas Station of Personal Car Drivers in Bangkok Metropolitan, Bangkok, Thailand, Rajamangala University of Technology Thanyaburi, 2007

[7] Vicha Phukanont. Fuel station choose factor of Wang Nam Yen district Sa-Kaeo Province. Independent study by Administration College, Burapha University, 2008

[8] Static group, Permanent Bureau of Transport, Annual report, Ministry of Transport, Bangkok, Thailand, 2016

[9] Surachai Ampawasuvan, Trip Attraction and Effect to Fuel Station on Arterial Road, King Mongkut's University of Technology North Bangkok, Thailand, 2017

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